SWITCHING

Define Switching?

A technology that offers a fast and easy way to physically isolate segment network traffic for performance and security reasons.

A **network switch** is a computer networking device that connects network segments.

Linksys 8-port consumer-grade switch.

Linksys 48 port switch.

Low-end network switches appear nearly identical to network hubs, but a switch contains more "intelligence" (and a slightly higher price tag) than a network hub. Network switches are capable of inspecting data packets as they are received, determining the source and destination device of that packet, and forwarding it appropriately. By delivering each message only to the connected device it was intended for, a network switch conserves network bandwidth and offers generally better performance than a hub.

In the past, it was faster to use Layer 2 techniques to switch, when only MAC addresses could be looked up in content addressable memory (CAM). With the advent of ternary CAM (TCAM), it was equally fast to look up an IP address or a MAC address. TCAM is expensive, but very appropriate for enterprise switches that use default routes plus a moderate number of other routes. For routers that need a full Internet routing table, TCAM may not be cost-effective.

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Function

As with hubs, Ethernet implementations of network switches are the most common. Mainstream Ethernet network switches support either 10/100 Mbit/s or 10/100/1000 Mbit/s ports Ethernet standards. Large switches may have 10 Gbit/s ports.

The **network switch**, **packet switch** (or just **switch**) plays an integral part in most Ethernet local area networks or *LANs*. Mid-to-large sized LANs contain a number of linked managed switches. Small Office, Home Office (SOHO) applications typically use a single switch, or an all-purpose converged device such as gateway access to small office/home office broadband services such as DSL router or cable, WiFi Router. In most of these cases, the end user device contains a router and components that interface to the particular physical broadband technology, as in the Linksys 8-port and 48-port devices. User devices may also include a telephone interface to VoIP.

Role of switches in networks

Network switch is a marketing term rather than a technical one. Switches may operate at one or more OSI layers, including physical, data link, network, or transport (i.e., end-to-end). A device that operates simultaneously at more than one of these layers is called a multilayer switch, although use of the term is diminishing.

In switches intended for commercial use, built-in or modular interfaces make it possible to connect different types of networks, for example Ethernet, Fiber Channel, ATM, and 802.11. This connectivity can be at any of the layers mentioned. While Layer 2 functionality is adequate for speed-shifting within one technology, interconnecting technologies such as Ethernet and token ring are easier at Layer 3.

Again, "switch" is principally a marketing term; interconnection of different Layer 3 networks is done by routers. If there are any features that characterize "Layer-3 switches" as opposed to general-purpose routers, it tends to be that they are optimized, in larger switches, for high-density Ethernet connectivity.

In some service provider and other environments where there is a need for much analysis of network performance and security, switches may be connected between WAN routers as places for analytic modules. Some vendors provide firewall, network intrusion detection, and performance analysis modules that can plug into switch ports. Some of these functions may be on combined modules

In other cases, the switch is used to create a "mirror" image of data that can go to an external device. Since most switch port mirroring provides only one mirrored stream, Ethernet hubs can be useful for fanning out data to several read-only analyzers. This is especially popular when using open-source network analysis tools running over Linux, such as the Snort intrusion detection system and the Wire shark (formerly ethereal) protocol analyzer.

Layer-specific functionality

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A modular network switch with 3 network modules (a total of 24 Ethernet and 14 Fast Ethernet ports) and one power supply.

While switches may learn about topologies at many layers, and forward at one or more layers, they do tend to have common features. Other than for computer-room very high performance applications, modern commercial switches use primarily Ethernet interfaces, which can have different input and output speeds of 10, 100, 1000 or 10000 megabits per second. Switch ports almost always default to full-duplex operation, unless there is a requirement for interoperability with devices that are strictly half duplex. Half-duplex means that the device can only send or receive at any given time, whereas full-duplex can send and receive at the same time.

At any layer, a modern switch may implement power over Ethernet (PoE), which avoids the need for attached devices, such as an IP telephone or wireless access point, to have a separate power supply. Since switches can have redundant power circuits connected to uninterruptible power supplies, the connected device can continue operating even when regular office power fails.

Layer-1 hubs versus higher-layer switches

An Ethernet hub, or repeater, is a fairly unsophisticated broadcast device, and rapidly becoming obsolete. Hubs do not manage any of the traffic that comes through them. Any packet entering a port is broadcast out or "repeated" on every other port, save the port of entry. Since every packet is repeated on every other port, packet collisions result, which slows down the network.

Hubs have actually become hard to find, due to the widespread use of switches. There are specialized applications where a hub can be useful, such as copying traffic to multiple network sensors. There is no longer any significant price difference between a hub and a low-end switch.

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Layer 2

A single LAN switch, operating at the MAC sub layer of the data link layer, may interconnect a small number of devices in a home or office. This is a trivial case of bridging, in which the switch learns the MAC address of each connected device. Compared to shared-medium LANs, a switch using micro segmentation prevents collisions on an Ethernet, and can provide effectively simultaneous paths among multiple devices. Single switches also can provide extremely high performance in specialized applications such as storage area networks

Switches may also interconnect using a spanning-tree protocol that allows the best path to be found within the constraint that it is a tree. In contrast to routers, bridges must have topologies with only one active path between two points. The older IEEE 802.1d spanning tree protocol could be quite slow, with forwarding stopping for 30-90 seconds while the spanning tree recon verged. A Rapid Spanning Tree Protocol was introduced as IEEE 802.1w, but the newest edition of IEEE 802.1d-2004, adopts the 802.1w extensions as the base standard.

Once a Layer 2 switch learns the topology through a spanning tree protocol, it forwards data link layer frames using some variant of bridging. There are four forwarding methods a Layer 2 switch can use:

Store and forward
: The switch buffers and, typically, performs a checksum on each frame before forwarding it on.

Cut through
: The switch reads only up to the frame's hardware address before starting to forward it. There is no error checking with this method.

Fragment free
: A method that attempts to retain the benefits of both "store and forward" and "cut through". Fragment free checks the first 64 bytes of the frame, where addressing information is stored. This way the frame will always reach its intended destination. Error checking of the actual data in the packet is left for the end device in Layer 3 or Layer 4 (OSI), typically a router.

Adaptive switching
: A method of automatically switching between the other three modes.

Note that cut-through switches have to fall back to store and forward if the outgoing port is busy at the time the packet arrives.

Note that these forwarding methods are not controlled by the user and are configured only by the switch itself.

Layer 3

Router is a marketing term for a Layer 3 switch, typically a router optimized for Ethernet interfaces. Like other switches, it connects devices to single ports for micro segmentation. The ports normally operate in full duplex.

Switches, even primarily Layer 2 switches, can be aware of Layer 3 multicast and increase efficiency by delivering the traffic of a multicast group only to ports where

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the attached device has signaled that it wants to listen to that group. In a switch not aware of multicasting and broadcasting, frames are also forwarded on all ports of each broadcast domain, but in the case of IP multicast this causes inefficient use of bandwidth. To work around this problem some switches implement IGMP snooping.

Layer 4

While the exact meaning of the term Layer-4 switch is vendor dependent, it almost always starts with a capability for network address translation, but then adds some type of load distribution based on TCP sessions.

The device may include a stateful firewall, a VPN concentrator, or be an IPSec security gateway.

Layer 7

As with the other types of switches, Layer 7 is a marketing term. They may distribute loads based on URL or by some installation-specific technique to recognize application-level transactions. A Layer-7 switch may include a web cache and participate in a content delivery network.

Types of switches

Form factor

A rack-mounted switch with network cables

- Rack mounted
- Non-rack mounted
- Chassis — with swappable "switch module" cards. e.g. Cisco's Catalyst switch

Configuration options

- *Unmanaged* switches — these switches have no configuration interface or options. They are typically found in SOHO or home environments.
- *Managed switches* — these are ones which allow access to one or more interfaces for the purpose of configuration or *management* of features such as Spanning Tree Protocol, Port Speed, VLANs, etc. High-end or "enterprise" switches provide a serial console and command-line access via telnet and Ssh, as well as management via SNMP. More recent devices also provide a web interface. Limited functions, such as a complete reset by pushing buttons

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on the switch are usually also provided. Managed switches are found in medium or large "enterprise" networks and though more expensive are of higher quality (e.g. with a backplane with higher transfer speeds). The task of managing usually requires understanding of Layer 2 networks (e.g. Ethernet).
    - *Smart* (or intelligent) switches — these are managed switches with a limited set of features. Likewise "web-managed" switches are switches which fall in a market niche between unmanaged and managed. For a price much lower than a fully managed switch they provide a web interface (and usually no CLI access) and allow configuration of basic settings, such as VLANs, port-speed and duplex.
    - *Web-managed* switches — Similar in functionality to a smart switch. A Web-managed switch is configured through a browser instead of via a desktop utility.

Traffic monitoring on a switched network

Unless port mirroring or other methods such as RMON or SMON are implemented in a switch, is difficult to monitor traffic that is bridged using a switch, because all ports are isolated until one transmits data, and even then only the sending and receiving ports can see the traffic. These monitoring features rarely are present on consumer-grade switches.

Two popular methods that are specifically designed to allow a network analyst to monitor traffic are:

- Port mirroring — the switch sends a copy of network packets to a monitoring network connection.
- SMON — "Switch Monitoring" is described by RFC 2613 and is a protocol for controlling facilities such as port mirroring.

Another method to monitor may be to connect a Layer-1 hub between the monitored device and its switch port. This will induce minor delay, but will provide multiple interfaces that can be used to monitor the individual switch port.

Typical switch management features

(In order of basic to advanced):

- Turn some particular port range on or off
- Link speed and duplex settings
- Priority settings for ports
- MAC filtering — and other types of "port security" features which prevent MAC flooding
- Use of Spanning Tree Protocol
- SNMP monitoring of device and link health
- Port mirroring (also named: port monitoring, spanning port, SPAN port, roving analysis port, link mode port)
- Link aggregation (also called: bonding/trunking)
- VLAN settings
- 802.1X network access control

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Link aggregation allows you to use multiple ports for the same connection achieving higher data transfer speeds. Creating VLANs can serve security and performance goals by reducing the size of the broadcast domain.

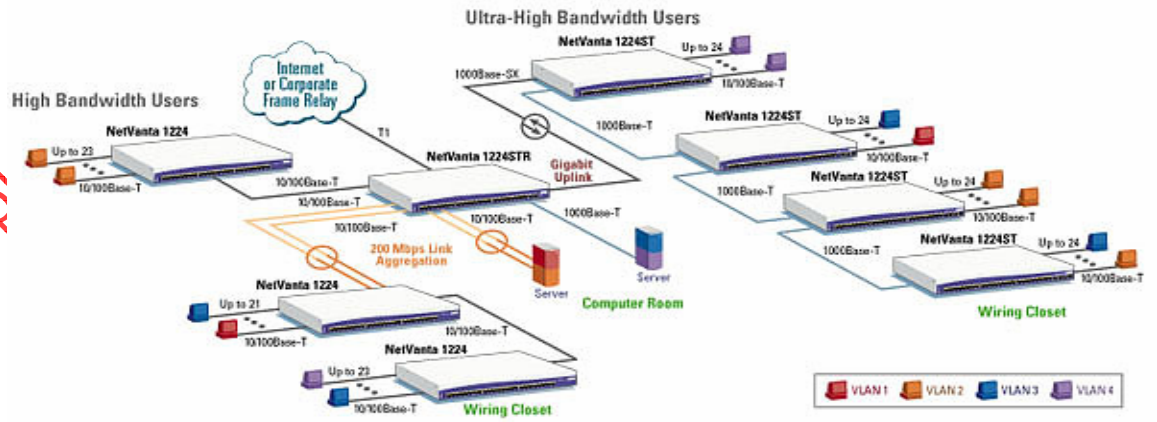
Virtual LAN

A **virtual LAN**, commonly known as a **VLAN**, is a group of hosts with a common set of requirements that communicate as if they were attached to the same wire, regardless of their physical location. A VLAN has the same attributes as a physical LAN, but it allows for end stations to be grouped together even if they are not located on the same LAN segment. Network reconfiguration can be done through software instead of physically relocating devices.

A VLAN can be thought of as a broadcast domain that exists within a defined set of switches. Ports on a switch can be grouped into VLANs in order to limit traffic flooding since it is limited to ports belonging to that VLAN and its trunk ports. Any switch port can belong to a VLAN. Packets are forwarded and flooded only to stations in the same VLAN. Each VLAN is a logical network, and packets destined for stations that do not belong to the same VLAN must be forwarded through a routing device. Each VLAN can also run a separate instance of the spanning-tree protocol (STP). Cisco switches support an independent implementation of STP for each VLAN by using per-VLAN spanning tree (PVST).

VLANs are created to provide the segmentation services traditionally provided by routers in LAN configurations. VLANs address issues such as scalability, security, and network management. Routers in VLAN topologies provide broadcast filtering, security, address summarization, and traffic flow management. By definition, switches may not bridge IP traffic between VLANs as it would violate the integrity of the VLAN broadcast domain.

Virtual LANs are essentially Layer 2 constructs, whereas IP subnets are Layer 3 constructs. In a campus LAN employing VLANs, a one-to-one relationship often exists between VLANs and IP subnets. Although it is possible to have multiple subnets on one VLAN or have one subnet spread across multiple VLANs. Virtual LANs and IP subnets provide an independent Layer 2 and Layer 3 constructs that map to one another and this correspondence is useful during the network design process.



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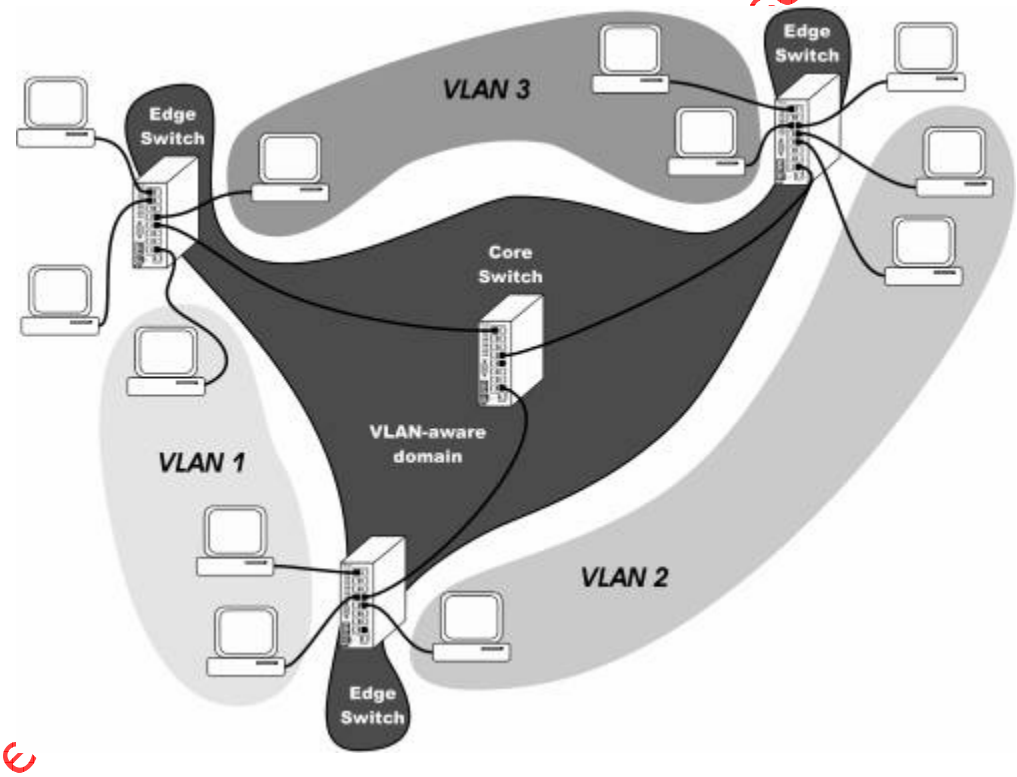
Motivation for VLAN

In a legacy network, users were assigned to networks based on geography and was limited by physical topologies and distances. By using VLAN, one can logically group networks and is no longer restricted by physical distance. This includes high-speed technologies such as:

- Asynchronous Transfer Mode (ATM)
- Fiber Distributed Data Interface (FDDI)
- Fast Ethernet
- Gigabit Ethernet
- 10-Gigabit Ethernet

By using VLAN, one can control traffic patterns and react quickly to relocations. VLANs provided the flexibility to adapt to changes in network requirements and allowed for simplified administration. Additionally, it provided an increased security measure and the ability to limit broadcasts.



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Protocols and design

The protocol used in configuring virtual LANs is IEEE 802.1Q. The IEEE committee defined this method of multiplexing VLANs in an effort to provide multi vendor VLAN support. Prior to the introduction of the 802.1Q standard, several proprietary protocols existed, such as Cisco's ISL (Inter-Switch Link, a variant of IEEE 802.10) and 3Com's VLT (Virtual LAN Trunk). ISL is no longer supported by Cisco.

Both ISL and IEEE 802.1Q tagging perform explicit tagging as the frame is tagged with VLAN information explicitly. ISL uses an external tagging process that does not modify the existing Ethernet frame whereas 802.1Q uses an internal tagging process that does modify the Ethernet frame. This internal tagging process is what allows IEEE 802.1Q tagging to work on both access and trunk links, because the frame appears to be a standard Ethernet frame.

The IEEE 802.1Q header contains the following:

* A 4-byte tag header containing a tag protocol identifier (TPID) and tag control information (TCI)
* A 2-byte TPID with a fixed value of 0x8100 that indicates that the frame carries the 802.1Q/802.1p tag information.

A TCI containing the following elements:

* Three-bit user priority
* One-bit canonical format indicator (CFI)
* Twelve-bit VLAN identifier (VID)-Uniquely identifies the VLAN to which the frame belongs

The 802.1Q standard can create an interesting scenario on the network. Recalling that the maximum size for an Ethernet frame as specified by IEEE 802.3 is 1518 bytes, this means that if a maximum-sized Ethernet frame gets tagged, the frame size will be 1522 bytes, a number that violates the IEEE 802.3 standard. To resolve this issue, the 802.3 committee created a subgroup called 802.3ac to extend the maximum Ethernet size to 1522 bytes. Network devices that do not support a larger frame size will process the frame successfully but may report these anomalies as a "baby giant."

Inter-Switch Link (ISL) is a Cisco proprietary protocol used to interconnect multiple switches and maintain VLAN information as traffic travels between switches on trunk links. This technology provides one method for multiplexing bridge groups (VLANs) over a high-speed backbone. It is defined for Fast Ethernet and Gigabit Ethernet, as is IEEE 802.1Q. ISL has been available on Cisco routers since Cisco IOS Software Release 11.1.

With ISL, an Ethernet frame is encapsulated with a header that transports VLAN IDs between switches and routers. ISL does add overhead to the packet as a 26-byte header containing a 10-bit VLAN ID. In addition, a 4-byte CRC is appended to the end of each frame. This CRC is in addition to any frame checking that the Ethernet frame requires. The fields in an ISL header identify the frame as belonging to a particular VLAN.

A VLAN ID is added only if the frame is forwarded out a port configured as a trunk link. If the frame is to be forwarded out a port configured as an access link, the ISL encapsulation is removed.

Early network designers often configured VLANs with the aim of reducing the size of the collision domain in a large single Ethernet segment and thus improving performance. When Ethernet switches made this a non-issue (because each switch

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port is a collision domain), attention turned to reducing the size of the broadcast domain at the MAC layer. Virtual networks can also serve to restrict access to network resources without regard to physical topology of the network, although the strength of this method remains debatable as VLAN Hopping is a common means of bypassing such security measures.

Virtual LANs operate at Layer 2 (the data link layer) of the OSI model. Administrators often configure a VLAN to map directly to an IP network, or subnet, which gives the appearance of involving Layer 3 (the network layer). In the context of VLANs, the term "trunk" denotes a network link carrying multiple VLANs, which are identified by labels (or "tags") inserted into their packets. Such trunks must run between "tagged ports" of VLAN-aware devices, so they are often switch-to-switch or switch-to-router links rather than links to hosts. (Note that the term 'trunk' is also used for what Cisco calls "channels" : Link Aggregation or Port Trunking). A router (Layer 3 device) serves as the backbone for network traffic going across different VLANs.

On Cisco devices, VTP (VLAN Trunking Protocol) maintain VLAN configuration consistency across the entire network. VTP uses Layer 2 trunk frames to manage the addition, deletion, and renaming of VLANs on a network-wide basis from a centralized switch in the VTP server mode. VTP is responsible for synchronizing VLAN information within a VTP domain and reduces the need to configure the same VLAN information on each switch.

VTP minimizes the possible configuration inconsistencies that arise when changes are made. These inconsistencies can result in security violations, because VLANs can cross connect when duplicate names are used. They also could become internally disconnected when they are mapped from one LAN type to another, for example, Ethernet to ATM LANE ELANs or FDDI 802.10 VLANs. VTP provides a mapping scheme that enables seamless trunking within a network employing mixed-media technologies.

VTP provides the following benefits:

* VLAN configuration consistency across the network
* Mapping scheme that allows a VLAN to be trunked over mixed media
* Accurate tracking and monitoring of VLANs
* Dynamic reporting of added VLANs across the network
* Plug-and-play configuration when adding new VLANs

As beneficial as VTP can be, it does have disadvantages that are normally related to the Spanning-Tree Protocol (STP) as a bridging loop propagating throughout the network can occur. Cisco switches run an instance of STP for each VLAN, and since VTP propagates VLANs across the campus LAN, VTP effectively creates more opportunities for a bridging loop to occur.

Before creating VLANs on the switch that will be propagated via VTP, a VTP domain must first be set up. A VTP domain for a network is a set of all contiguously trunked switches with the same VTP domain name. All switches in the same management domain share their VLAN information with each other, and a switch can participate in

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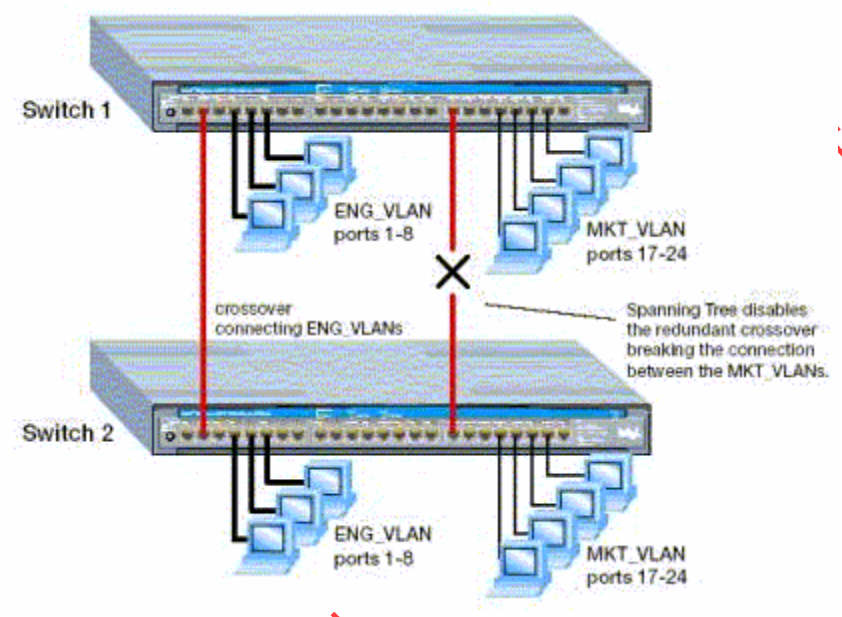
only one VTP management domain. Switches in different domains do not share VTP information.

Using VTP, each Catalyst Family Switch advertises the following on its trunk ports:

* Management domain
* Configuration revision number
* Known VLANs and their specific parameters



Establishing VLAN memberships

The two common approaches to assigning VLAN membership are as follows:

* Static VLANs
* Dynamic VLANs

Static VLANs are also referred to as port-based VLANs. Static VLAN assignments are created by assigning ports to a VLAN. As a device enters the network, the device automatically assumes the VLAN of the port. If the user changes ports and needs access to the same VLAN, the network administrator must manually make a port-to-VLAN assignment for the new connection.

Dynamic VLANs are created through the use of software packages such as Cisco Works 2000. With a VLAN Management Policy Server VMPS, an administrator can assign switch ports to VLANs dynamically based on information such as the source MAC address of the device connected to the port or the username used to log onto that device. As a device enters the network, the device queries a database for VLAN membership. See also FreeNAC which implements a VMPS server.

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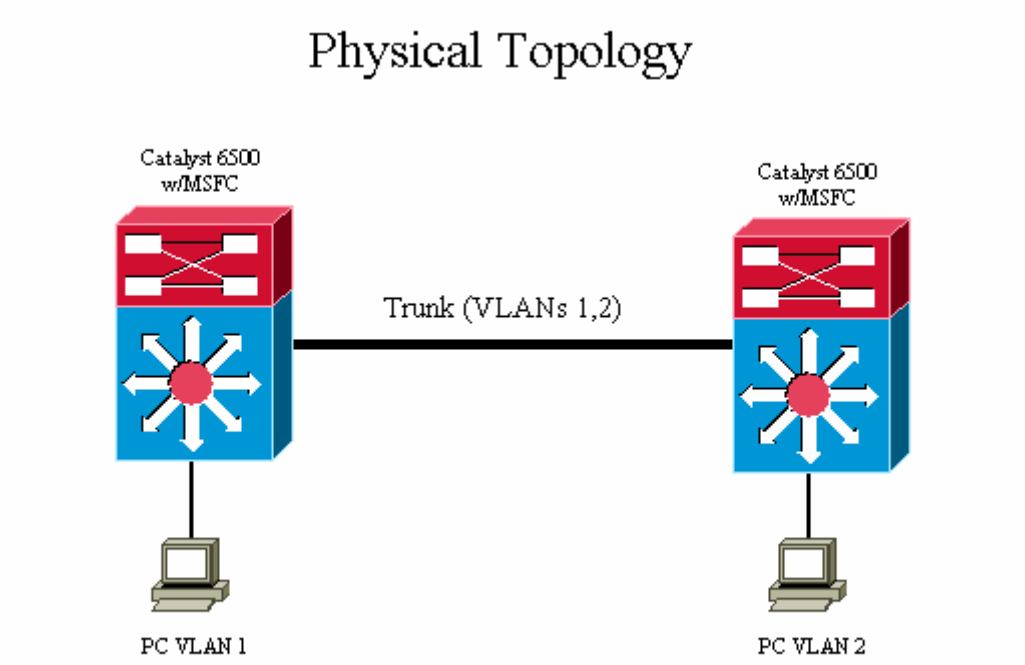

Port-based VLANs

With port-based VLAN membership, the port is assigned to a specific VLAN independent of the user or system attached to the port. This means all users attached to the port should be members in the same VLAN. The network administrator typically performs the VLAN assignment. The port configuration is static and cannot be automatically changed to another VLAN without manual reconfiguration.

As with other VLAN approaches, the packets forwarded using this method do not leak into other VLAN domains on the network. After a port has been assigned to a VLAN, the port cannot send to or receive from devices in another VLAN without the intervention of a Layer 3 device.

The device that is attached to the port likely has no understanding that a VLAN exists. The device simply knows that it is a member of a subnet and that the device should be able to talk to all other members of the subnet by simply sending information to the cable segment. The switch is responsible for identifying that the information came from a specific VLAN and for ensuring that the information gets to all other members of the VLAN. The switch is further responsible for ensuring that ports in a different VLAN do not receive the information.

This approach is quite simple, fast, and easy to manage in that there are no complex lookup tables required for VLAN segmentation. If port-to-VLAN association is done with an application-specific integrated circuit (ASIC), the performance is very good. An ASIC allows the port-to-VLAN mapping to be done at the hardware level.

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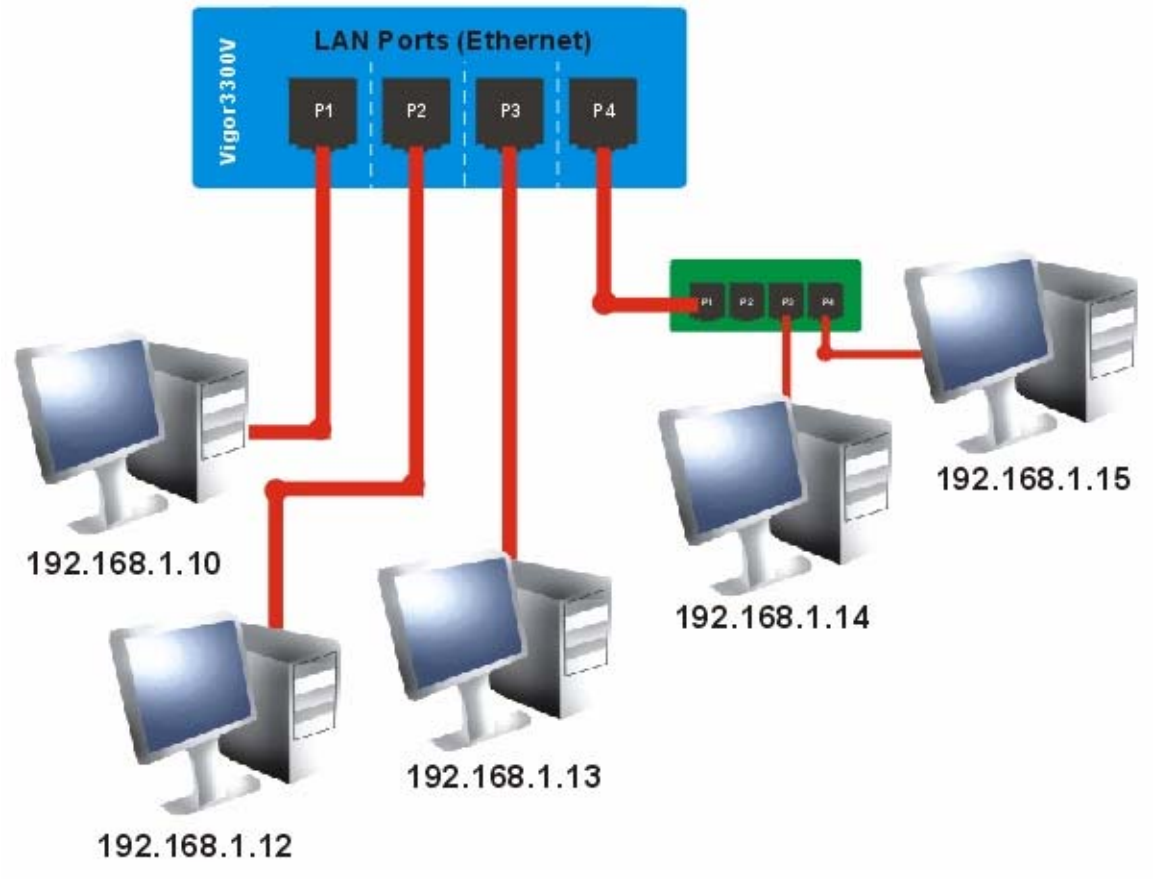

Local area network

A **local area network (LAN)** is a computer network covering a small geographic area, like a home, office, or group of buildings. The defining characteristics of LANs, in contrast to Wide Area Networks (WANs), include their much higher data transfer rates, smaller geographic range, and lack of a need for leased telecommunication lines.

Ethernet over unshielded twisted pair cabling, and Wi-Fi are the two most common technologies currently, but ARCNET, Token Ring and many others have been used in the past.

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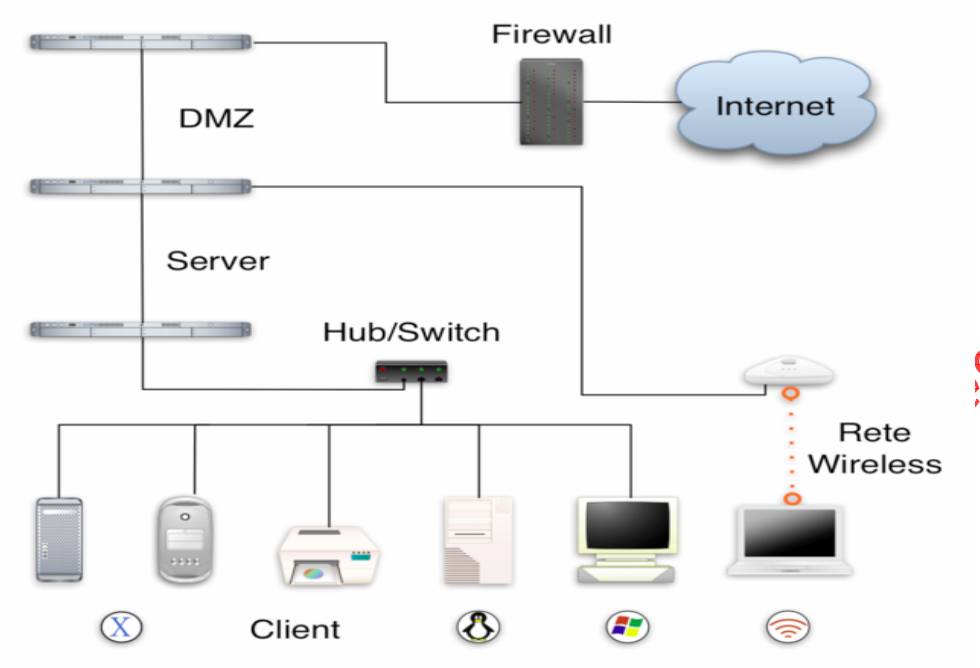

Local area network scheme

Multilayer switch

A **multilayer switch (MLS)** is a computer networking device that switches on OSI layer 2 like an ordinary network switch and provides extra functions on higher OSI layers.

Cisco Systems Gigabit Switch Router

Layer 3 Switching

The major difference between the packet switching operation of a router and that of a Layer 3 switch is the physical implementation. In general-purpose routers, packet switching takes place using a microprocessor, whereas a Layer 3 switch performs this using application-specific integrated circuit (ASIC) hardware.

Multilayer Switch (MLS) - OSI layer 3 and/or 4

A Multilayer Switch (MLS) can prioritize packets by the 6 bits in IP DSCP (differentiated services Code Point). These 6 bits were used in the "old days" for Type of Service (ToS).

The following 4 mappings are normally available in an MLS:

- From OSI layer 2, 3 or 4 to IP DSCP (if IP packet) and/or VLAN IEEE 802.1p.
- From VLAN IEEE 802.1p to IP DSCP.
- From IP DSCP to VLAN IEEE 802.1p.
- From VLAN IEEE 802.1p to port queue.

Many MLSs implement QoS differentiated services and/or integrated services in hardware.

Some MLS's are also able to route between VLAN and ports like a common router. The routing is normally as quick as switching (at wire speed). According to Cisco, Level 3 switches are basically routers that switch based on Layer 3 information, the basic difference being processing speed and/or the way they do the switching; Level 3 switches use ASICs/hardware instead of the CPU/software that a router would.

Pre-owned CISCO 6509 Multilayer Switch

Layer 4-7 switch, web-switch, content-switch

Some switches can use up to OSI layer 7 packet information; they are called layer 4-7 switches, content-switches, content services switches, web-switches or application-switches.

Content switches are typically used for load balancing among groups of servers. Load balancing can be for HTTP, HTTPS and/or VPN, or for any application TCP/IP traffic

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using a specific port. Load balancing often involves NAT so that the client of the load-balanced service is not fully aware of precisely which server is handling its requests. Some of the layer 4-7 switches can NAT at wire speed. Content switches can often also be used to perform standard operations such as SSL encryption/decryption to reduce the load on the servers receiving the traffic, and to centralise the management of digital certificates.

Some types of application require that repeated requests from a client are directed at the same application server. Since the client isn't generally aware of which server it spoke to earlier, content switches define a notion of stickiness. For example, requests from the same source IP address are directed to the same application server each time. Stickiness can also be based on SSL Ids, and some content switches can even use cookies to provide this functionality.

The ServerIron® family of Layer 4-7 switches & Load Balancer

Layer 4 Load Balancer

A typical network router simply sends incoming packets onto the appropriate IP address on its network. A **layer 4 router**, more correctly a NAT with port and transaction awareness, uses a little trickery and sends incoming packets to one or more machines which are hidden behind a single IP address.

The Layer 4 refers to the 7 layer OSI model. The router is on the Transport Layer and makes decisions on where to send the packets. Modern load balancing routers can use different rules to make decisions on where to route traffic. This can be based on least load, or fastest response times, or simply balancing requests out. This is also a redundancy method, so if one machine is not up, the router will not send traffic to it.

Load Balancing Router

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CISCO SWITCH PRODUCTS: (http://www.cisco.com)

Product Portfolio

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3. Cisco Catalyst 6500 Series Switches 4. Cisco Catalyst 6500 Virtual Switching System 1440 5. Cisco Catalyst 4900 Series Switches 6. Cisco Catalyst 4500 Series Switches 7. Cisco Catalyst 3750 Metro Series Switches 8. Cisco Catalyst 3750 Series Switches 9. Cisco Catalyst 3750-E Series Switches 10. Cisco Catalyst 3560 Series Switches 11. Cisco Catalyst 3560-E Series Switches 12. Cisco Catalyst 3550 Series Switches 13. Cisco Catalyst 2960 Series Switches 14. Cisco Catalyst 2955 Series Switches 15. Cisco Catalyst 2950 Series Switches 16. Cisco Catalyst 2940 Series Switches 17. Cisco Redundant Power Systems	Concentrators **Other WAN Switching Products:** 1. Cisco BPX/IGX/IPX WAN Software 2. Cisco MGX 8880 Media Gateways 3. Cisco IGX 8400 Series Switches

D-Link Switches (http://www.dlink.com)

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Unmanaged Fast-Ethernet Small /Medium office. Ideal for light to medium data applications where no switch management is required.						
 DES-1105	5-Port 10/100 Desktop Switch				 DES-1108	8-Port 10/100 Desktop Switch
 DES-1008PA	8-Port 10/100 Desktop Switch with 4 PoE Ports				 DSS-16+	16-Port 10/100 Desktop Switch
 DSS-24+	24-Port 10/100 Switch + 2 Optional Port 100BASE-FX Uplinks				 DES-1024D	Express Ether Network 24-Port 10/100 Rack mountable Switch
 DES-1026G	24-Port 10/100 + 2 Gigabit 1000BASE-TX Switch					
Unmanaged Gigabit Small / Medium office. Ideal for medium to heavy data applications where no switch management is required. Can be used as an aggregation switch for multiple fast Ethernet edge switches.						

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DGS-2205	5-Port 10/100/1000 Desktop Switch				DGS-2208	8-Port 10/100/1000 Desktop Switch
DGS-1016D	16-Port 10/100/1000 Rack mountable Switch				DGS-1024D	24-Port 10/100/1000 Rack mountable Switch
Smart Fast-Ethernet Small / Medium office. Ideal for light to medium data applications. Features web based management and features such as Quality of Service and VLANs. Provides added network security. Can be used as a central switching device for small office connectivity or at the network edge.						
DES-1316	Web Smart 16-Port 10/100 with 8 PoE 802.3af ports Switch				DES-1228	Web Smart 24-Port 10/100 + (4) 1000BASE-T Ports + 2 Combo Ports Switch
DES-1228P	Web Smart 24-Port PoE 10/100 + (4) 1000BASE-T Ports + 2 Combo Ports Switch				DES-1252	Web Smart 48-Port 10/100 + 2 Combo GbE + (2) 1000BASE-T Ports Switch
Smart Gigabit Small / Medium office. Ideal for medium to heavy voice, video, and data applications. Features web based management and features such as Quality of Service and VLANs. Provides added network security. Can be used as a central switching device in a small office or as an aggregation switch for multiple fast Ethernet or Gigabit unmanaged edge switches.						
DGS-1216T	Web Smart 16-Port 10/100/1000+2 combo SFP Switch				DGS-1224T	Web Smart 24-Port 10/100/1000 + 2 combo SFP Switch
DGS-1248T	Web Smart 48-Port 10/100/1000 + 4 combo SFP Switch					
Layer 2 Fast-Ethernet Small / Medium / Large office. Ideal for light to medium voice, video, and data applications. Features management through web GUI and Command Line Interface. Supports multiple features designed to provide advanced quality of service, network management, and security.						
DES-3228PA	xStack Managed 24-Port 10/100 Stackable L2 PoE Switch, 4 Gigabit Copper Ports, 2 Combo SFP				DES-3028	Managed 24-Port 10/100 Stackable Switch + 4 Gigabit Ports + 2 Combo SFP Slots
	Managed 24-Port 10/100 Stackable PoE Switch + 4 Gigabit Ports + 2 Combo SFP Slots					Managed 48-Port 10/100 Stackable Switch + 4 Gigabit Ports + 2 Combo SFP Slots

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DES-3028P					DES-3052	
DES-3052P	Managed 48-Port 10/100 Stackable PoE Switch + 4 Gigabit Ports + 2 Combo SFP Slots				DES-3010FA	Managed 8-Port 10/100 Switch + 1 Gigabit Port + (1) 100BASE-FX MMF Port
DES-3010GA	Managed 8-Port 10/100 Switch + 1 Gigabit Port + 1 SFP Slot				DES-3010PA	Managed 8-Port 10/100 PoE Switch + 1 Gigabit Port + 1 SFP Slot
DES-3226L	Managed 24-Port 10/100 Switch + 2 combo Gig copper/SFP uplinks				DES-3526	Managed 24-Port 10/100 Stackable L2 Switch, 2 Gigabit Copper Ports, 2 Combo SFP
DES-3550	Managed 48-Port 10/100 Stackable L2 Switch, 2 Gigabit Copper Ports, 2 Combo SFP					
Layer 2 Gigabit Medium / Large office. Ideal for medium to heavy voice, video, and data applications. Features management through web GUI and Command Line Interface. Supports multiple features designed to provide advanced quality of service, network management, and security. Can be used as a central switching device in a small office or as an aggregation switch for multiple edge switches. May support 10Gigabit interfaces for uplinking to Storage Area Network devices or Servers. May support redundant stacking ability.						
DGS-3100-24	Managed 24-Port Gigabit Stackable Layer 2 Switch + 4 combo SFP + 20 Gig Stacking				DGS-3100-24P	Managed 24-Port Gigabit Stackable PoE Layer 2 Switch + 4 combo SFP + 20 Gig Stacking
DGS-3100-48	Managed 48-Port Gigabit Stackable Layer 2 Switch + 4 combo SFP + 20 Gig Stacking				DGS-3100-48P	Managed 48-Port Gigabit Stackable PoE Layer 2 Switch + 4 combo SFP + 20 Gig Stacking
DXS-3227	xStack 24-Port Gigabit Wireless-Ready Switch + (4) Combo SFP Ports + (1) Fixed XFP Port + (2) Optional 10-Gig Copper/Fiber Uplinks				DXS-3227P	xStack 24-Port PoE Gigabit Wireless-Ready Switch + (4) Combo SFP Ports + (1) Fixed XFP Port + (2) Optional 10-Gig Copper/Fiber Uplinks
DXS-3250	xStack 48-Port Gigabit Wireless-Ready Switch + (4) Combo SFP Ports + (2) Optional 10-Gig Copper/Fiber Uplinks				DGS-3024	24-Port 10/100/1000 Switch + 4 combo SFP ports

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DGS-3224TGR	24-Port 10/100/1000 Switch + 4 combo SFP ports				DGS-3048	48-Port 10/100/1000 Switch + 4 Combo SFP Uplinks
Layer 3 Fast-Ethernet Large / Enterprise environments. Ideal solution when multiple dynamic routing devices are present on the network. Management through GUI or CLI. Advanced QoS, Security, and support for dynamic routing protocols such as RIP and OSPF. Can be used as a core network routing device for multiple Layer 3 departmental level switches. May support redundant stacking ability.						
DES-3828	xStack Managed 24-Port 10/100 Stackable L3 Switch, 4 Gigabit Copper Ports, 2 Combo SFP				DES-3828P	xStack Managed 24-Port 10/100 Stackable L3 PoE Switch, 4 Gigabit Ports, 2 Combo SFP
Layer 3 Gigabit Large / Enterprise Environments. Ideal for large IP routed networks. Often a stackable solution with support for 10 Gigabit uplinking. Supports advanced QoS, Security, and Dynamic Routing functions. Can be used at the network core as central network router and aggregation device.						
DGS-3612G	xStack Multilayer IPv6 12-Port 1000BASE-X SFP Switch + 4 Combo 1000BASE-T Ports				DGS-3627	xStack Multilayer IPv6 24-Port Gigabit Switch + 4 Combo SFP + 3 Optional 10Gig Uplinks + 40Gig Stacking
DGS-3650	xStack Multilayer IPv6 48-Port Gigabit Switch + 4 Combo SFP + 2 Optional 10Gig Uplinks + 40Gig Stacking				DGS-3324SR	xStack 24-Port 10/100/1000 Switch + 4 combo SFP, 10Gig Stacking
DGS-3324SRi	xStack 24-Port 10/100/1000 Switch + 8 combo SFP, 10Gig Stacking				DXS-3326GSR	xStack 24-Port SFP Switch + 4 combo 10/100/1000T+ 2 10GbE ports
DXS-3350SR	xStack 48-Port 10/100/1000 Switch+ 4 combo SFP + 2 10GbE ports					
Wireless Ideal for seamless converged wired and wireless networks. Allows for seamless roaming and centralized AP management. Supports management through GUI and CLI. Can be stackable. May support 10 Gigabit uplinking and / or stacking.						
DWS-3227	xStack 24-Port Gigabit Unified Wireless Switch + 10 Gigabit Uplinks				DWS-3227P	xStack 24-Port Gigabit Unified Wireless Switch with PoE + 10 Gigabit Uplinks

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DWS-3250	xStack 48-Port Gigabit Unified Wireless Switch + 10 Gigabit Uplinks				DWS-1008	AirPremier 8-Port Wireless Switch with PoE
Modular Chassis Switches						
DES-6500	9-slot 160Gbps Chassis Switch				DES-6504	12-Port 100BASE-FX MMF LC Module For DES-6500 Chassis
DES-6506	24-Port RJ21 to RJ45 Patch Panel For DES-6500 Chassis				DES-6507	12-Port 10/100/1000 Module + 2 SFP For DES-6500 Chassis
DES-6509	12-Port 1000BASE-X SFP Module For DES-6500 Chassis				DES-6510	24-Port 10/100 RJ21 Module For DES-6500 Chassis
DES-6512	2 Port 10Gigabit XFP Module for DES-6500 Chassis					
Switch Accessories						
DEM-410CX	1-Port 10GBase-CX4 Module for DGS-3600 Series				DEM-410X	1-Port 10-Gigabit XFP Module for DGS-3600 Series
DEM-211	100BASE-FX Multimode LC SFP Transceiver				DEM-310GM2	1000BASE-SX+ Gigabit Interface Converter
DEM-310GT	1000BASE-LX Mini Gigabit Interface Converter				DEM-311GT	1000BASE-SX Mini Gigabit Interface Converter
DEM-340T	4-port 10/100/1000BASE-T Module				DGS-712	10/100/1000BASE-T Copper SFP Transceiver
DEM-411S	48Gbps Stacking Kit for XStack 3200 Series Switch				DEM-411T	1-Port 10GBASE-CX4 Copper Module

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DEM-411X	1-Port 10GBASE-X XFP Module				DEM-420CX	2-Port 10 Gigabit CX-4 Module for xStack 3300 Series
DEM-420X	2-Slot XFP 10Gigabit Uplink Module				DEM-421XT	10Gigabit XFP (10GBASE-SR)
DEM-422XT	10Gigabit XFP (10GBASE-LR)				DES-102F	2-Port 100BASE-FX Fiber Module for DSS-24+
DFE-855	Fast Ethernet Media Converter				DMC-700SC	Media Converter
Redundant Power Supply Units (RPSU)						
DPS-200	60Watt Redundant Power Supply Unit				DPS-500	140Watt Redundant Power Supply Unit
DPS-510	Redundant Power Supply				DPS-800	2-Slot Redundant Power Supply Unit Open Chassis
DPS-900	8-Slot Open Chassis for Redundant Power Supply Units				DES-6511	Redundant Power Supply For DES-6500 Chassis
SNMP Management Software for all Managed Switches						
DS-510P	D-View 5.1 SNMP Network Management System Professional Version				DS-510S	D-View 5.1 SNMP Network Management System Standard Version

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Edge switches

Multilayer, high port density switches providing scalable, reliable network infrastructures:

Intelligent Edge switches	**Description**	**Accessories**
Switch 5400zl series	Consists of Layer 2/3/4 switches that offer the most advanced intelligent edge capability in a chassis (6-slot and 12-slot) form factor.	Modules, Power Supplies, Mini-GBIC, Transceiver, License and Software
Switch 3500yl series	Consists of Layer 2/3/4 switches that offer the most advanced intelligent edge capability in a stackable (24-port and 48-port) form factor.	Modules, Power Supplies, Mini-GBIC, Transceiver, License and Software
Switch 5300xl series	Offers Layer 2/3/4 switching in a modular 4 or 8-slot chassis.	Modules, Power Supplies, Mini-GBIC and License
Switch 3400cl series	Exceptionally affordable 24 and 48-port 10/100/1000 intelligent EDGE stackable switches with optional 10-Gb uplink capability.	Modules, Power Supplies, Mini-GBIC and Transceiver
Edge switches — Managed	**Description**	**Accessories**
Switch 4200vl series	A series of modular chassis that provides a flexible cost-effective LAN solution as an alternative to stackables.	Modules, Power Supplies, Mini-GBIC, Software and Transceiver
Switch 4100gl series	Convergence-ready and easy to use switches available in compact 8-slot and 4-slot modular form factors.	Modules, Power Supplies, Mini-GBIC and Transceiver
Switch 2900 series	Reliable 24 and 48-port 10/100/1000 basic Layer 3 stackable switches, each with 4 dual-functionality ports and 4 integrated 10GbE ports (two X2 + two CX4) for high-speed stacking and uplinks.	Mini-GBIC, Transceiver and Software
Switch 2800 series	Consists of two switches; a 24 or 48-port stackable with 10/100/1000 ports and 4 dual-functionality ports for up to four Gigabit fiber uplinks.	Power Supplies, Mini-GBIC and Transceivers
Switch 2600 series	A collection of cost-effective, stackable, multi-layer, managed switches with 48, 24, or 8 auto-sensing 10/100 ports and dual-personality ports for 10/100/1000 or mini-GBIC connectivity.	Power Supplies and Mini-GBIC
Switch 2600 PWR	A series of IEEE 802.3af-compliant switches ideal for Power over Ethernet; providing up to 15.4 Watts per port.	Power Supplies and Mini-GBIC
Switch 2810 series	Flexible 24 and 48-port 10/100/1000 Layer 2 stackable switches, each with 4 dual-functionality ports for up to 4	Power Supplies, Mini-GBIC, Software and Transceivers

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	Gigabit fiber uplinks.	
Switch 2510 series	A managed, Layer 2, 24-port 10/100 switch with 2 dual-personality Gigabit ports providing 10/100/1000-T or mini-GBIC connectivity.	Mini-GBIC, Software and Transceivers
Switch 2500 series	Consists of cost-effective, stackable, managed 24 and 12-port switches with 10/100 auto-sensing per port and 2 open transceiver slots for Gigabit or 100Base-FX.	Stacking Kit and Transceiver
Edge switches — Web Managed	**Description**	**Accessories**
Switch 1800 series	Consists of 8 and 24-port Gigabit switches with Web management capability offering a small form factor 10/100/1000 switch or a 24-port 10/100/1000 switch with 2 dual-personality ports for optional fiber uplinks.	Mini-GBIC and Software
Switch 1700 series	A series ideal for businesses making the transition from unmanaged to managed networks, designed with no fan, enables quiet operation for deployment in open spaces with an Industry-leading warranty.	Mini-GBIC and Software
Edge switches — Unmanaged	**Description**	**Accessories**
Switch 2700 series	Consists of cost-effective, unmanaged 24 and 8-port switches with 10/100/1000 auto-sensing per port.	
Switch 2300 series	Consists of cost-effective, unmanaged 24 and 12-port switches with 10/100 auto-sensing per port and 2 open transceiver slots for Gigabit or 100Base-FX uplinks.	Transceiver
Switch 2124	A cost-effective, unmanaged 24-port switch with 10/100 auto-sensing per port and 1 open transceiver slot for a 100Base-FX uplink.	Transceiver
Switch 1400 series	Plug-and-play switch for high-bandwidth connectivity, silent operation via a fanless design with an industry-leading warranty.	Mini-GBIC
Switch 408	A compact, unmanaged 8-port 10/100 switch	Mounting Kit

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Multilayer, high port density switches providing scalable, reliable network infrastructures:

Core switches	Description	Accessories
Switch 9300m series	Delivers high-performance capabilities and investment protection for medium and large enterprise networks.	Modules, Power Supplies, Mini-GBIC and Transceiver
Interconnect fabric	**Description**	**Accessories**
Switch 8212zl	A high performance, full-featured chassis switch solution that offers reduced complexity in a complete Core-to-Edge network solution and delivers to market the industry's 1st core switch with a lifetime warranty.	Modules, Power Supplies, Mini-GBIC and Transceiver
Switch 8100fl series	Delivers high-availability, high-bandwidth, and cost-effective fabric interconnectivity for the Adaptive EDGE Architecture.	Modules, Power Supplies, Mini-GBIC and Transceiver
Distribution/aggregator	**Description**	**Accessories**
Switch 6400cl series	Flexible 6-port 10-Gigabit stackable switches with optional 10-Gigabit 2-port add-on modules.	Modules, Power Supplies and Transceiver
Switch 6200yl series	Offers Layer 2/3/4 capability in a 1U stackable format to aggregate network traffic from the edge of the network to the core.	Modules, Mini-GBIC, Transceiver and Software
Switch 6108	A cost-effective, stackable, multi-layer managed 8-port switch with 6 auto-sensing 10/100/1000 ports and 2 dual-personality ports for 10/100/1000 or mini-GBIC connectivity.	Mini-GBIC
Switch 5400zl series	Consists of Layer 2/3/4 switches that offer the most advanced intelligent edge capability in a chassis (6-slot and 12-slot) form factor.	Modules, Power Supplies, Mini-GBIC, Transceiver, License and Software

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